Claims

1. An imaging apparatus comprising:

means for integration of spatial, spectral and temporal features, and optionally other physiologic data or calibration data, in a spectral and temporal multimodal imaging system for the evaluation of biological systems and stimuli; and

means for fusing a thermal image or other imaging modalities and hyperspectral data cube for assessment of biological processes.

2. The imaging apparatus of claim 1 wherein the integrated features are two or more of visible or infrared hyperspectral images, visible or infrared brightfield images, thermal images, fluorescence images, Raman images, or combinations thereof.

3. The imaging apparatus of claim 1 further comprising:

a specific UV, visible or infrared light source, and

means for collecting two or more of visible or infrared hyperspectral images, visible or infrared brightfield images, thermal images, fluorescence images, Raman images, or combinations thereof.

4. The imaging apparatus of claim 1 wherein the light source can be controlled to limit the illumination to only a single or group of spectral bands.

5. The imaging apparatus of claim 1 wherein the multimodal imaging systems includes a collection optic that is an endoscope.

6. The imaging apparatus of claim 1 further comprising inputs for signals from instruments monitoring a biological function to allow the synchronization of the collection of images to the biological process.

7. The imaging apparatus of claim 1 further comprising:

on-board CCD chip filter and processing electronics to perform data operations prior to transmission of signal to increase processing speed; and

inputs for a physiological monitoring system.

8. The imaging apparatus of claim 1 further comprising:

sensors for image fusion and alignment;

alignment mechanisms for aligning multiple optical paths;

normal color video for displaying data and for camera alignment and aiming; and

a storage system for recording and logging of real-time or near real-time output.

9. The imaging apparatus of claim 1 further comprising means for stabilizing and integrating imagery and data sets in a temporally and geometrically dynamic environment in such a way that the integrated data sets can be interpreted.

10. The imaging apparatus of claim 1 further comprising an image registration device to maintain image centering.

11. The imaging apparatus of claim 1 further comprising a reference frame device that is visible in the images across multiple spectra as well as in thermal images for multi-modal fusion.

12. The imaging apparatus of claim 1 further comprising:

a tracked imaging apparatus comprising a means of creating a unified spatial mosaic of individual hyperspectral image cubes taken at various locations and times.

13. A method comprising the steps of:

integrating spatial, spectral and temporal features, and optionally physiologic data, with a spectral and temporal multimodal imaging system for the evaluation of biological systems and stimuli; and

fusing a thermal image or other imaging modalities with hyperspectral images.

14. The method of claim 13 further comprising the step of interlacing thermal images and hyperspectral images with a time-dependent reference.

15. The method of claim 13 further comprising the step of selecting a wavelength to maximize diagnostic information for a specific tissue state or anticipated end diagnostic goal.

16. The method of claim 13 wherein the selection step is performed by multivariate image and spectral processing algorithms to extract information from the plurality of images and spectra for real-time or near real-time assessment.

17. The method of claim 13 wherein the target is skin.

18. The method of claim 13 wherein the target is an organ or a tissue

19. The method of claim 13 wherein the analysis step determines the spatial distribution of oxyhemoglobin, deoxyhemoglobin and methemoglobin.

20. The method of claim 19 wherein the analysis step determines a total hematocrit by calculating the area under the oxyhemoglobin, deoxyhemoglobin and methemoglobin spectrum or the intensity at their respective wavelengths, and a total blood volume by pairing a total hematocrit with perfusion data from a broadband thermal camera.

21. The method of claim 19 wherein the analysis step determines a state of perfusion, demonstrates state of oxygen extraction, neurohumoral, physiological or pathological circumstances and in specific spatial patterns.

22. The method of claim 13 further comprising the step of gating each image of a hyperspectral image set as well as the adjunct thermal images to a biological function such as the cardiac cycle, breathing, pulse, or muscle contraction, to allow data collection from moving samples.

23. The method of claim 13 wherein the analysis step identifies and classifies chemical species other than hemoglobins.

24. The method of claim 13 further comprising the steps of:

registering multiple images in the hyperspectral cube acquired at various wavelengths and at different times so that each corresponding pixel in every plane images the same point in space.

incorporating a high spatial and temporal resolution imaging device that is used as a reference in which each spectral image in the cube is registered.

25. The method of claim 24, further comprising the step of utilizing automatic feature extraction techniques to localize landmarks throughout the hyperspectral imaging cube.

26. The method of claim 24, further comprising the step of registering and analyzing multiple hyperspectral image sets taken over time.

27. The method of claim 24, further comprising the step of registering a hyperspectral image set with a three dimensional spatial medical image.

28. The method of claim 27 wherein the fusion is performed with a real-time or near real-time hyperspectral imaging device and a 3D medical image.

29. The method of claim 24, further comprising the step of performing real-time or near real-time visualization of the full spectral information at a given location by registering a real-time or near real-time trackable instrument with the images.

30. The method of claim 27 wherein the three dimensional spatial medical image is selected from the group consisting of MR, CT, PET, SPECT, ultrasound, or combinations thereof.

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